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APPLICATION  
FOR  
15 UNITED STATES LETTERS PATENT  
FOR

METHOD FOR TREATMENT DISEASES ASSOCIATED WITH A  
DETERIORATION OF THE MACROCIRCULATION,  
20 MICROCIRCULATION AND ORGAN PERFUSION

BY

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5           **METHOD FOR TREATMENT DISEASES ASSOCIATED WITH A  
                  DETERIORATION OF THE MACROCIRCULATION,  
                  MICROCIRCULATION AND ORGAN PERFUSION**

10                   **CROSS REFERENCE TO RELATED APPLICATIONS**

The present application is a continuation of U.S. Serial No. 09/095,472, filed June 10, 1998 (allowed), which claims priority to U.S. Serial No. 60/050,018, filed June 13, 1997 and to U.S. Serial No. 60/049,636, filed June 16, 1997, which applications  
15   are incorporated herein by reference in their entirety.

**BACKGROUND OF THE INVENTION**

The present invention relates to a new method for the effective therapeutic treatment  
20   of diseases associated with a deterioration of the macrocirculation, microcirculation and organ perfusion to achieve an improvement of the local environment and the metabolic situation and to aim at the improvement of organ function or the stabilization of organ function with imminent functional deterioration.

25   The present invention relates especially to a new method for the effective treatment of cardiological and systemic diseases.

In the past ophthalmological diseases like age-related maculopathy (AMD) retinal vein occlusion, diabetic retinopathy, arterial occlusion, uveal effusion syndrome,  
30   NAION, Stargardt's-disease, uveitis, and maculopathy of different origin could not

5 be treated with a generally accepted therapy. For example for the treatment of  
AMD lasering treatments, radiation and operation were used. However these  
methods had no effect on the further development of the disease in many of the  
patients suffering therefrom. This principle has now been extended to cardiological  
diseases. Therapy refractory angina pectoris of coronary heart disease is the major  
10 disease. CHD is a severe progressive disease which occurs in the elderly. It is  
considered to be the most frequent cause of death in patients beyond an age of 65  
years. There are more than 10 Million Americans suffering from this disease. An  
increasing number of patients after standard therapies such as coronary angioplasty,  
bypass operation and drug therapy are exhausted, demand new approaches.  
15 Extracorporeal haemorheo-therapy (rheopheresis, rheo-apheresis) is a so far not  
considered or applied new treatment.

There is an increasing number of patients who underwent coronary angioplasty  
and/or coronary bypass surgery and are now again suffering from anginal pain due  
20 to the progression of the atherosclerotic disease. Even the new technique of trans-  
myocardial laser revascularization does not help them for more than 1 – 2 years.  
They then again depend on the conventional pharmacological therapy of coronary  
heart disease such as nitrates, beta-blockers and calcium antagonists, which become  
more and more ineffective during this stage of the disease. New types of antianginal  
25 medications are not expected to be developed during the next decade. As these  
patients finally have no therapeutic alternative in the very last stage of the disease,  
there is a great need for a new and effective therapeutic treatment of the above  
mentioned cardiological and systemic diseases.

- 5 In the early '90s the inventors of the present invention observed that the elimination of fibrinogen and plasma proteins of higher molecular weight led to an increase of the visual acuity of patients suffering from macular disease and uveal effusion syndrome (Brunner, Borberg et al. Acta Medica Austriaca 1991, 18, supplement 1, page 63 to 65). In this document 1 patient with uveal effusion syndrome and 16  
10 patients with maculopathy were treated. The haematocrit was reduced by erythrocyte apheresis. Fibrinogen and plasma proteins were eliminated by plasma exchange using a solution of 5% human albumin. The visual acuity of 9 of the patients with maculopathy was significantly increased after one therapy.
- 15 In a further publication from 1991 (Brunner, Borberg et al., Dev. Ophthalmol., Karger (Public.) Basel, 1992, vol. 23, p. 275 to 284) it was studied whether clinical improvements could be obtained by plasma exchange therapy with patients suffering from intermediate uveitis using a solution of 5% human albumin. It was found out that both of the haemorheological and immunodulatory effects of this treatment  
20 could be beneficial in this disease. Human albumin as well as preserved serum were used as exchange fluids.

However, a general concept for the effective therapeutic treatment of cardiological diseases was not described in these documents.

- 25 Therefore it was the object of the invention to provide a method for the effective treatment of diseases associated with a deterioration of the macrocirculation, microcirculation and organ perfusion to achieve an improvement of the local environment and the metabolic situation and to aim at the improvement of organ  
30 function or the stabilization of organ function with imminent functional

5     deterioration, especially for the effective treatment of cardiological and systemic diseases.

### SUMMARY OF THE INVENTION

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This object is solved by a method, which comprises the treatment of blood of patients by extracorporeal plasmapheresis techniques.

15

In a preferred embodiment the diseases are selected from the group comprising arterial occlusion, venous thrombosis, apoplexia, cerebral infarction, transitory ischaemic attack, multiple cerebral infarction syndrome, dementia, Alzheimer's disease, diabetes mellitus, burns, Septicaemia (Sepsis), Raynaud's syndrome, ulceration of the skin due to rheological alternations, ophthalmologic diseases especially maculopathy, retinal vein occlusion and uveal effusion syndrome, cardilogic and systemic diseases.

20

According to a preferred embodiment of the invention the cardiological and systemic diseases which can be treated are selected from the group comprising therapy refractory angina pectoris of patients with coronary heart disease, diseases of coronary microcirculation ("small vessel disease," "syndrome X"), disturbances of cerebral microcirculation (e.g. Morbus Binswanger), diabetic cardiomyopathy, diabetic retinopathy, diabetic nephropathy, diabetic neuropathy, pulmonary hypertension, artery occlusion, retinal vein occlusion.

- 5 In a further preferred embodiment the plasmapheresis technique is selected from the following techniques: blood cell plasma separation, plasma differential separation, plasma differentiation precipitation, plasma differential adsorption, plasma differential filtration.
- 10 The treatment comprises the steps of withdrawing the blood from the patient, treatment of the blood by the plasmapheresis techniques mentioned above and re-infusing the treated blood.

#### BRIEF DESCRIPTION OF THE DRAWINGS

- 15 Figure 1 is a schematic drawing of a patient connected to an extracorporeal system for plasmapheresis.

#### Detailed description of the invention

- 20 Haemapheresis (apheresis) is defined as the on line separation of blood into blood components. The process of separation refers to the blood cells or to the blood fluid (plasma). Haemapheresis procedures are preformed using centrifugal or filtration techniques to modulate blood composition as for instance for the donation of blood
- 25 components or to perform therapies. The modulation of the blood composition using hemapheresis procedures can generally be attributed to both elimination and dilution. The standard techniques are world wide distributed and under increasing usage.

5 Rheology is defined as follows. The fluidity of blood as a non Newtonian fluid is characterized from rheological parameters, namely from viscosity. The viscosity of the blood in the human organism is determined from several variables, the most important being the concentration of blood cells and the protein content of the plasma. Within the plasma high molecular weight proteins, such as low density  
10 lipoprotein cholesterol, alpha-2-macroglobulin, immunoglobulin M, fibrinogen, are major determinants. Thus, hyperviscosity syndromes are mainly either due to hypercellularity as it occurs for instance in leukemias or due to an excessively elevated concentration of plasma proteins as for instance in Waldenstrom's disease. The treatment of diseases characterized from hyperviscosity has for many years  
15 been performed using haemapheresis techniques by removing such an excess of cells or plasma. These therapies are also generally known and world wide applied.

Cardiological diseases and the other systemic diseases mentioned are for unknown reasons hardly or not at all treated with haemapheresis techniques. Some of them,  
20 such as therapy refractory coronary heart disease are without a generally accepted therapy, though various attempts have without success been made to inhibit the progress of the disease. These failures may be due to therapeutic helplessness and also lack of knowledge on the pathogenesis of some of these conditions. Among several hypotheses one of them tries to relate the clinical deterioration with an  
25 insufficient and decreasing blood perfusion. All kinds of treatments used hitherto have the blood vessels as object of their direct or indirect target. Alternatively, an improvement of organ perfusion for instance due to an optimization of blood fluidity could well be used for the treatment of cardiological diseases associated with a disorder of the microcirculation.

30

- 5 According to the above mentioned theory it was assumed from the inventors, that a positive clinical effect might be observed in patients suffering from myocardial circulatory diseases and many other diseases of the microcirculation if the haemorheology could be improved following erythrocyte apheresis in combination with an elimination of fibrinogen and plasma proteins of higher molecular weight.
- 10 Preliminary observations supported this hypothesis indeed. (R. Brunner, H. Borberg, J. Kadar, M. Heidel, K. Heidner, W. Konen) Erythrocyte apheresis in combination with elimination of fibrinogen and plasma proteins of higher molecular weight in macular disease and uveal effusion syndrome. AMA 1991; 18 (suppl. 1): 63 – 65). As a correction of the haematocrit is not often necessary, the studies
- 15 concentrated more on an optimisation of plasma viscosity applying plasma exchange against 5% human albumin (R. Brunner, H. Borberg, J. Kadar, A. Hoffman, W. Konen, M. Heidel, K. Heidner, in Intermediate Uveitis, WRF Boke, K.F. Manthey, R.B. Nussenblatt (eds), Dev. Ophthalmol, Karger (publ.), Basel 1992; 23: 275 – 284.) These observations were also supported from preliminary observations in
- 20 cardiological diseases such as refractory angina pectoris in end-stage coronary heart disease. (M. Tauchert, A. Sonntag, B. Weidmann, A. Gaczkowski, R. Brunner, H. Borberg: Extracorporeal hemorheo-therapy of refractory angina pectoris. Jpn. J. Apheresis 1997; 16, 1: 35 – 37)
- 25 Subsequently, several plasma differential separation techniques were investigated and compared with plasma exchange therapy. It could be shown, that plasma viscosity, standardized whole blood viscosity at an hct of 0.45 and standardized erythrocyte aggregation at an hct of 0.30 were still significantly decreased one day after therapy. The values of the standardized whole blood viscosity showed a non-
- 30 linear, haematocrit-dependent rise, whereas the erythrocyte aggregation revealed the

- 5 maximum value near a haematocrit of 0.3. A reduction in all adjusted haematocrits was demonstrated. Also, native whole blood viscosity and erythrocyte aggregation were lowered within the same range while the haematocrit was only slightly diminished. The high molecular weight substances of the plasma (Lipids such as total cholesterol, LDL-cholesterol, HDL-cholesterol, proteins such as alpha-2-
- 10 macroglobulin, immunoglobulin including fibrinogen) were decreased between 20 – 70% (R. Brunner, R.A. Widder, P. Walter, H. Borberg, K. Oette. Change in haemorheological and biochemical parameters following membrane differential separation. Int. J. Artif. Organs 1995: 18, 12:794 – 798).
- 15 Finally, several plasma differential separation techniques were examined from the inventors to improve the techniques applicable for an extracorporeal haemorheotherapy of ophthalmological diseases.

Techniques applicable for the use within the invention consist of blood cell – plasma

20 separation, also named primary separation, plasma differential separation, also named secondary separation. After the process of separation and elimination of either cells (if necessary) and/or plasma proteins whole blood is returned to the patient. However, these techniques are not obligatory, as whole blood perfusion of filters or adsorbers may also be applied.

25

Blood cell – plasma separation (primary separation)

Centrifugal separation based on continuous or discontinuous flow principles (e.g. IBM model 2997, COBE Spectra, FRESenius AS 104, DIDECO Excel,

30 HAEMONETICS model 50), can successfully be applied to separate blood cells

5 from blood plasma. Alternatively flat sheet membrane (COBE TPE) or hollow fiber  
plasma separators (ASAHI OP – 05) were and can be used to obtain cell free  
plasma. The separated plasma is discarded to be substituted with human albumin, a  
mixture or combination of human albumin with other fluids or other fluids alone  
(plasma exchange therapy).

10

For anticoagulation usually heparin, citrate or a combination of both may be applied.  
Other upcoming anticoagulation procedures are equally applicable. The access to  
the circulation can be established on a veno-venous basis from one antecubital vein  
to the other or from a central venous access to a peripheral vein or using an artificial  
15 access to the circulation applying for instance a shunt, a Shaldon catheter or any  
other catheter using for instance Seldinger's technique. Single needle techniques  
may also be used.

Plasma differential separation (secondary separation)

20

As plasma exchange therapy may be characterized from safety drawbacks as for  
instance the transfer of infectious agents such as viruses or prions, secondary or  
plasma differential separation techniques are preferred. They consist of plasma  
differential precipitation with heparin, adsorption or absorption of plasma proteins  
25 or plasma filtration. All technologies for secondary plasma separation are  
preferably applied on-line.

Plasma differential precipitation

30 Plasma differential separation is performed adding an excess of heparin to the

- 5     separated plasma, establishing a pH of 5.12 to precipitate heparin binding plasma proteins, separating the precipitate from the plasma by hollow fiber filtration, and removing the heparin excess via adsorption. Any other plasma protein precipitating technique may also be applied.

10     Plasma differential adsorption

- Plasma differential separation is performed permitting the separated plasma to pass through an adsorption column eliminating plasma proteins for instance using hydrophobic interaction chromatography (applying for instance an ASAHI TR 350  
15     adsorption column) or affinity chromatography (applying for instance an LDL-apheresis CAQ adsorption column) or any other related adsorption technology. (As mentioned above, instead of perfusing adsorption columns with separated plasma, whole blood perfusion in biocompatible systems may also be applied).

20     Plasma differential filtration

- Plasma differential separation is performed permitting the separated plasma to pass through a secondary filter eliminating plasma proteins according to the pore size of the membranes (for example ASAHI AC 1730, ASAHI AC 1760, ASAHI Rheofilter  
25     2000, ASAHI AC 1770, KURARAY Evaflux filters with different pore sizes, DIDECO Albusave).

Retransfusion

- 30     If whole blood perfusion is used, the blood cleared from the eliminated components

5 is returned to the patients. If plasma differential separation is used, the blood components without the cells and/or plasma are returned to the patient.

A typical example of plasma differential separation using filtration as an example is shown in Fig. 1. (Step 1: Blood is removed from a pump into the extracorporeal  
10 circuit, where cells are separated from the plasma in a plasma separator. The plasma separator may consist of either a centrifugal or a filtration apparatus. Step 2: The separated plasma is either discarded and replaced (plasma exchange), or, alternatively, permitted to pass through one or more secondary devices eliminating the precipitated, adsorbed or filtered plasma. Step 3: The purified blood is returned  
15 to the patient. Note that whole blood perfusion devices are correspondingly simpler.)

Treatments were performed processing about 50 to 200% of the patient's plasma volume preferably 120% on day one and about 50 to 150% preferably 60-80% of the  
20 patient's plasma volume on day 3 or 4 with either technique described above. Blood samples were drawn prior to and one day after the second treatment to measure the efficacy parameters. Two treatments were considered as one cycle. The interval from one cycle to another was generally 4 – 5 weeks. A total of 5 treatment cycles were applied.

25

Other treatment approaches mainly but not only used for maintenance therapy consisted of a single treatment or one single treatment at different intervals. The definition of the interval is related to the choice of the separation techniques, thus other approaches are equally possible.

5 Patients who were treated with a method according to the invention reported about daily life improvements such as reduced number of heart attacks, an improved work capacity, better social contacts and an increased degree of independence.

The present invention will be further understood by reference to the following  
10 examples.

#### EXAMPLES

##### Example 1

15 Treatment of patients with therapy refractory angina pectoris (n=10).

The mean age of these patients was  $63 \pm 5$  years. All had undergone maximum pharmacological treatment, eight of them coronary bypass surgery, two of the latter  
20 even transmyocardial laser revascularization (TMLR).

For these patients with therapy refractory angina pectoris treatment consisted of two treatment sessions with a one day interval (1 treatment cycle). The patients were hospitalized for 5 days. Measurements were carried out one day prior to the first  
25 treatment session and 24 hours after the second treatment session. The mean duration of treatment was 28 months, the mean interval between the double treatment sessions (treatment cycles) was 6 weeks.

We applied the following extracorporeal treatment procedures: plasma exchange  
30 with 5% human albumin solution, selective adsorption using the tryptophan-

5 polyvinylalcohol adsorber TR-350 (Asahi Medical Tokyo) and membrane  
differential separation with the Cascadeflo AC-1760 (Asahi Medical Tokyo). The  
amount of plasma volume perfused varied between 80-120% of the patient's plasma  
volume. A centrifugal blood separator (IBM 2997, Cobe Spectra) and the OP-05  
10 hollow fiber filter (Asahi Medical Tokyo) were used for primary separation. The  
blood flow was established between two antecubital veins. Anticoagulation  
consisted of heparin (2500 units) injected as a bolus prior to therapy and ACD-A  
citrate continuously infused at a ratio of 1:16 during the course of treatment.  
Patients with severe systemic diseases like malignomas, cardial decompensation,  
hepatitis, HIV infection as well as severe hypotony were excluded. Plasma and  
15 standardized, whole blood viscosity at a haematocrit of 45% were measured using a  
coneplate system (CS-Rheometer Carri Med Ltd., Dorking, UK) at 37 degrees  
Celsius and standardized erythrocyte aggregation at a haematocrit of 30% was  
measured applying the Mini-Aggregometer (Myrenne GmbH, Roetgen, Germany)  
(7).

20 Clinical parameters for the evaluation of the efficacy of the extracorporeal  
hemorheotherapy were the number of anginal attacks per day (plotted in a protocol  
book), frequency of nitroglycerin applications and dosage per day (plotted in a  
protocol book) and work capacity (W x min) as determined by bicycle ergometry.

25

## Results

Severe side effects did not occur. Two patients experienced hypotonic episodes  
with a drop of blood pressure not below 90/60 mmHg. They were treated with the

- 5 substitution of 250 ml 5% human albumin. No further medical treatment was required.

Biochemical parameters

- 10 Fibrinogen as one of the most important factors of plasma viscosity was decreased from  $3,61 \pm 0,16$  g/l prior to the first treatment to  $1,81 \pm 0,09$  after the first double procedure. Prior to the last treatment performed the value was  $3.05 \pm 0.11$  g/l and decreased due to the procedure to  $1.71 \pm 0.09$  g/l.
- 15 Total protein was only affected slightly from extracorporeal rheotherapy ( $6,83 \pm 0,09$  g/dl before and  $5,72 \pm 0,07$  g/dl after the first procedure,  $6,82 \pm 0,1$  g/dl prior to and  $5,95 \pm 0,04$  g/dl following the hitherto last intervention.

- Immunoglobulin M (IgM) decreased from  $142,4 \pm 5,8$  mg/dl to  $103,1 \pm 6,8$  mg/dl during the first treatment; the values before and after hitherto last therapy were  $143,8 \pm 8,9$  mg/dl and  $85,3 \pm 4,0$  mg/dl correspondingly.
- 20

- Immunoglobulin A (IgA) was influenced to a similar extent ( $143,5 \pm 7,9$  mg/ to  $124,3 \pm 4,1$  mg/dl prior to and after the first therapy resp.  $163,4 \pm 1,9$  mg/dl to  $94,4 \pm 8,9$  mg/dl before and after the hitherto last therapy.
- 25

- Immunoglobulin G (IgG) decreased from  $992,2 \pm 71,2$  mg/dl to  $879,1 \pm 52,3$  mg/dl during the first and from  $1010,5 \pm 91,5$  mg/dl to  $702,1 \pm 149,2$  mg/dl during the last treatment. The decrease of immunoglobulins due to the rheological therapy was obviously not substantial enough to lead to any infection whatsoever.
- 30

- 5     There was no significant effect on the hematocrit ( $41,0 \pm 0,9$  % resp.  $41,7 \pm 0,9$  % during the first intervention;  $41,8 \pm 0,6$  % resp.  $42,3 \pm 0,6$  % during the last treatment).

- The number of platelets remained nearly unchanged from the treatments ( $215,3 \pm 6,3 \times 10^3$  per microliter resp.  $213,1 \pm 5,1 \times 10^3$  during the first treatment and  $207,0 \pm 4,5 \times 10^3$  resp.  $207,9 \pm 10^3$  per microliter during the last procedures).
- 10

- Low density lipoprotein cholesterol (LDL-C) was reduced from  $127,2 \pm 17,0$  mg/dl to  $71,1 \pm 11,2$  g/dl within the first therapy. The effect of the second treatment was similar ( $122,8 \pm 160$  mg/dl to  $59,0 \pm 7,2$  mg/dl). Lipoprotein ( $\alpha$ ) was influenced similarly ( $89,1 \pm 6,8$  mg/dl to  $45,0 \pm 8,0$  mg/dl resp.  $93,9 \pm 51,0 \pm 5,1$  mg/dl). The decrease of the lipoproteins under apheresis is a considerable contribution to the alteration of the plasma viscosity.
- 15

- 20     Clinical results

#### Attacks of angina pectoris

- The number of angina pectoris attacks per day was reduced due to the rheological treatment from  $5,7 \pm 0,4$  to  $2,3 \pm 0,3$  following the first treatment and from  $4,5 \pm 0,3$  to  $1,8 \pm 0,3$  by the hitherto last treatment procedure. Some patients were completely free from anginal pain for the first days or even weeks after therapy. During the last third of the interval between the therapeutic procedures (4 – 9 weeks with a mean of 6 weeks), the number of angina pectoris attacks rose again. The therapy was
- 25

5 repeated, when the frequency and intensity of attacks was nearly the same as before therapy.

Dosage of nitroglycerin.

10 The number of nitroglycerin applications (and thus the daily dosage) was reduced to the apheresis from  $3,8 \pm 0,3$  to  $1,7 \pm 0,3$  after the first treatment. Prior to the hitherto last rheoapheresis treatment the number of daily doses was  $2,9 \pm 0,4$  and was reduced to  $1,3 \pm 0,2$ .

15 Work capacity

Work capacity as determined using bicycle ergometry is a reliably reproducible parameter if the measurements are always performed during the same daytime and under otherwise identical conditions. The patient starts the ergometry with a  
20 standard minimal load (generally 50 Watt) and terminates it with the onset of angina pectoris and/or exhaustion. The time from start to stop multiplied with the work load represents the individual work capacity.

Work capacity was increased from  $209 \pm 22$  W x min from prior to the first  
25 treatment to  $369 \pm 27$  W x min after the hitherto last therapy.

Discussion

The concentration of high molecular weight substrates in the plasma is a major  
30 determinant of the plasma viscosity and thus whole blood viscosity. The intensity

5 and duration of a diminution of such substrates due to plasma differential separation  
used for rheotherapy is superior to other rheological treatments such as isovolaemic  
haemodilution or the application of urokinase. The application of this innovative  
concept of extracorporeal haemorheotherapy to 10 patients with therapy performed  
over a period of 28 months demonstrated both safety and efficacy in this group of  
10 seriously sick patients. The therapeutic effect decreased or eliminated the patients'  
complaints, increased their quality of life and has a life prolonging effect.

Though an interval of six weeks was appropriate for most of the patients it is  
necessary to individualize it according to the laboratory (mainly the clinical-  
15 chemical and hemorheological) and clinical data of the patient.

#### Example 2

Treatment of patients with disorders of the microcirculation for instance "small  
20 vessel disease," "syndrome X" (n = 3)

The etiology and pathogenesis of so named "small vessel disease" or "syndrome X"  
are unknown. The syndrome is characterized by angina pectoris and positive stress  
tests however angiographically normal epicardial coronary arteries and slow  
25 coronary blood flow. There is, however, evidence of structural and functional  
alteration of prearteriolar myocardial blood vessels with a severely reduced  
vasodilator reserve due to endothelial dysfunction. Extracardiac symptoms such as  
migraine, pathological pain perception, neuro-regulatory abnormalities and a  
reduced vasodilator reserve of the forearm hint to a systemic disease. A high  
30 prevalence of pathological brain SPECT examinations in patients with cardiac

- 5 “syndrome X” supports the hypothesis of a generalized vascular disorder (B. Weidmann, W.C. Janen, A. Bock, J. Assheuser, M. Tauchert. Technetium – 99m – HMPAO brain SPECT in patients with syndrome X. Am. J. Cardiol. 1997; 79: 959 – 961.
- 10 3 patients ( $56 \pm 10$  years of age) with “syndrome X” as documented by exercise test, characteristic blood flow in angiographically normal coronary arteries, angina pectoris under stress and pathologic brain SPECT were treated with extracorporeal hemorheotherapy using differential filtration over a period of 31 months at intervals of 3 – 8 (mean 6) weeks. The biochemical parameters complied with those
- 15 demonstrated in example 1. Clinical test parameters followed for evaluation were the number of angina pectoris attacks per day, the number of daily applied nitroglycerin applications, the work capacity and the symptoms of cerebro-vascular insufficiency as described from the patients.

20 Results

The biochemical parameters were influenced from the extracorporeal hemorheotherapy the same way and extent as described in example 1 for patients with refractory angina pectoris with severe, progressed coronary heart disease.

25

The number of anginal attacks per day was reduced from 6,3 to 2 following the first treatment and from 5,9 to 2,0 by the hitherto last therapeutic procedure.

- The frequency of nitroglycerin applications per day decreased from 5,0 to 1,5 as
- 30 related to the first treatment and from 4,8 to 1,4 to the hitherto last therapy.

- 5 The work capacity rose from 189 W x min to 333 W x min under the first apheresis application and from 201 W x min to 349 W x min to the hitherto last treatment.

The symptoms of cerebrovascular insufficiency (forgetfulness, fatigue, reduced vigilance) were considerably improved.

10

### Conclusions

- “Syndrome X” of the heart is well known as a syndrome with angina pectoris, positive stress tests and slow flow in angiographically normal epicardial coronary arteries. Some pathogenetic findings indicate, that “syndrome X” of the heart is the first expression of a microvascular disease of systemic character, appearingly due to endothelial dysfunction. Any efficacious therapy was so far unknown. The therapeutic effects observed in the group of patients described indicate that the alteration of the plasma and whole blood viscosity as obtained by extracorporeal haemorheotherapy is a therapeutically useful treatment approach.
- 15
- 20

### Example 3

#### Treatment of diabetes mellitus

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#### Treatment of patients with diabetic gangrene of the foot (n = 4)

- Micro- and macroangiopathy of the whole arterial system are very common in patients with a history of long lasting diabetes mellitus. Among other complications stroke, myocardial infarction, diabetic cardiomyopathy, diabetic renal failure,
- 30

5 diabetic retinopathy, diabetic neuropathy or gangrene of the toes and feet are common.

In the late stage of diabetic angiopathy leading for instance to gangrene of the foot due to ischaemia, there is up to now no effective treatment available. Thus surgical  
10 amputation of necrotic toes, the forefoot or forefeet or finally of the whole foot are necessary after gangrene appeared.

Four patients ( $66 \pm 5$  years of age) with beginning gangrene of toes or parts of their feet were treated with extracorporeal haemorheotherapy in the same manner as  
15 described before. The following prerequisites were fulfilled:

1. Long lasting diabetes mellitus
2. Plasma fibrinogen higher than 5.0 g/l
3. No further treatment alternative due to exhaustion of conventional antiischemic therapy including vascular surgery and intraarterial infusions.
- 20 4. Beginning gangrene
5. Indication for surgical amputation as given from an experienced vascular surgeon

#### Results

25

All four patients demonstrated an improved perfusion of the gangrenous areas ready following the first therapeutic session. After three treatment cycles (six single therapies), any need for further surgical intervention was denied from both, the vascular surgeon and the patient.